CHAPTER 2 NEW MEXICO'S SURFACE WATER BASINS:

Their Physical Descriptions, Current Contamination Problems, and Ongoing Remediation Efforts

The New Mexico Water Quality Control Commission (WQCC)~~, through this document,~~ continues a comprehensive geographic approach to protect all the State's water resources. New Mexico has performed a great deal of such planning since the adoption of the WQCC's Basin Plans in 1974 under the federal mandate of § 208 of the Clean Water Act (CWA) [33 U.SC. 1288].The WQCC recognizes eleven distinct basins within the State, which are identified mainly by surface hydrology. In one case, however, (the Rio Grande Basin with its Upper, Middle and Lower segments) convenient landmarks serve to divide the basin into regions based on types of water use, availability and socioeconomic differences. This chapter summarizes New Mexico's individual surface water basins as currently recognized by the WQCC with descriptive narratives on physical features and boundaries, typical climatic conditions, and some of each basin's topical environmental concerns. Remediation efforts by State and federal agencies are briefly discussed in those areas of current concern.

THE RIO GRANDE BASIN

The Rio Grande flows approximately 1,900 miles from its headwaters in Colorado to the Gulf of Mexico, virtually splitting the State down the middle for over 400 miles. For water quality management purposes, the Rio Grande in New Mexico has been divided into three sections: the Upper Rio Grande, which extends along the Rio Grande from the Colorado/New Mexico State Line to the Angostura Diversion Works; the Middle Rio Grande, which includes the reach from the Angostura Diversion Works to the headwaters of Elephant Butte Reservoir; and the Lower Rio Grande, which runs from the headwaters of Elephant Butte Reservoir to the International Boundary and Water Commission sampling station above American Dam.

The Upper Rio Grande

The Upper Rio Grande watershed covers approximately 7,500 square miles in North-Central New Mexico (**WQCC 1976e**~~1~~) and extends over portions of seven counties including Rio Arriba, Taos, Santa Fe, Los Alamos, Sandoval, Mora and San Miguel. It is bounded on the north by the Colorado/New Mexico State Line, and extends south to the Angostura Diversion Works just above the confluence of the Rio Grande and Jemez River. The eastern boundary of the section runs along the major ridge line of the Sangre de Cristo Mountains, while the western boundary follows the Continental Divide through Rio Arriba County, then travels southeast through Sandoval County to the San Felipe Pueblo boundary line.

The Rio Grande bisects the north-central portion of the State from north to south for a distance of about 143 miles. The river is fed by several tributaries including the Rio Chama with its main tributaries, the Rio Tusas, Vallecitos Creek, Rio Ojo Caliente, El Rito, Abiquiu Creek, and Rio del Oso, as well as Santa Clara Creek and the Rito de los Frijoles which drain the areas located west of the Rio Grande. The Red River, Rio Hondo, Rio Pueblo de Taos, Embudo Creek, Rio Medio, Santa Cruz River, Rio Frijoles, Pojoaque River, Santa Fe River, Galisteo Creek and Las Huertas Creek carry drainage from the east. Not all of these tributaries sustain perennial surface flow throughout their entire lengths. It should be noted, however, that almost all of the perennial tributaries to the Rio Grande in New Mexico can be found within the Upper Rio Grande.

The topography of the area is characterized by mountains interspersed by river valleys and sparsely vegetated foothills. Elevations range from 5,100 feet south of the City of Santa Fe up to 13,161 feet at the summit of Wheeler Peak. Several other mountain peaks in the region rise to elevations of well over 12,000 feet.

For its first fifty miles inside New Mexico, the Rio Grande winds through a deep basalt-lined gorge. At some points this canyon is as much as 1,200 feet from the riverbed to the rim, with sheer walls on either side. The Rio Grande gorge has been designated a Wild and Scenic River by the United States Congress, as has the four-mile segment of the Red River where it forms the Red River Canyon above its confluence with the Rio Grande. This designation indicates these river segments are free-flowing, of high water quality, and of significant aesthetic value.

The Rio Grande travels through the Rio Grande Gorge and into the Española Valley where it is intersected by the Rio Chama, its largest tributary. Just below Otowi Bridge, the Rio Grande enters a 16-mile stretch through White Rock Canyon before it is again intersected, this time by the ephemeral Santa Fe River, in the Santo Domingo Valley above Cochiti Dam. Almost 100% of the time the Santa Fe River percolates into the ground and reappears as springs below the dam in the old Santa Fe riverbed. Only once has Cochiti Reservoir been high enough that the Santa Fe River actually entered it. Below Cochiti Dam, the river continues into the San Felipe Pueblo, which defines the southern boundary of the Upper Rio Grande at the Angostura Diversion Works.

The Middle Rio Grande

The Middle Rio Grande watershed (~~2~~**WQCC 1976a**) covers approximately 11,884 square miles of land in parts of ten counties including Rio Arriba, Sandoval, McKinley, Valencia, Cibola, Santa Fe, Bernalillo, Torrance, Catron and Socorro. It is located along the main floodplain of the Rio Grande Valley. Principal tributaries are the Jemez River, the Rio Puerco/Rio San Jose and the Rio Salado.

The topography of the Middle Rio Grande varies from mountains to relatively flat, broad plains. The eastern portion extends from the ridges of the Sandia and Manzano mountains, down along the Los Piños and Fra Cristobal mountain ranges to the northwestern side of the Jorñada del Muerto. The boundary then cuts across the Rio Grande at the headwaters of Elephant Butte Reservoir, returns northwest along the San Mateo Mountains, follows the eastern side of the Plains of San Agustin and the Northern Plains, and joins the Continental Divide south of Bluewater to just north of Cuba, marking the western and northern boundaries of the section. The boundary line then proceeds eastward, taking in a part of the Jemez Mountains and finally crossing the Rio Grande at the Angostura Diversion Works.

The Rio Grande Valley follows a chain of sub-basins in the middle of the Rio Grande rift. These sub-basins have been down-faulted thousands of feet; the rift is bounded on both sides by major fault zones. On the east side of the rift, uplifting of mountain highlands has occurred; volcanoes and igneous intrusions mark the west side of the rift. Sands, gravels, silts and clays carried in tributaries or in runoff from adjacent highlands have filled the sub-basins in some places to an estimated depth of 10,000 feet. The Rio Grande trough is 25 to 30 miles wide and about 85 miles long in the Albuquerque and Belen sub-basins. The valleys are bounded on each side by mesas which rise abruptly to heights of 300-500 feet above the valley floor and then slope gently upward to the foothills. Socorro Valley, which begins at the San Acacia constriction and ends at the San Marcial constriction is about 38 miles long. The incised river portion is much narrower than the floodplain, which is about eight to twelve miles wide, bordered by mountains to the west and highlands on the east.

Most of the surface water in the Middle Rio Grande is supplied by runoff and stream flow from the Upper Rio Grande. Exceptions are perennial tributaries in the Jemez Mountains which contribute to the Jemez River and its principal tributary, the Guadalupe River, as well as the upper reaches of the Rio Puerco and its principal tributary, the Rio San Jose. Large amounts of ground water are held in storage in the alluvial materials of the Rio Grande trough. Most water uses, primarily municipal and industrial, in the Rio Grande Basin are met with ground water supplies; an exception is irrigated agriculture which relies primarily upon surface water. The use of surface waters of the Rio Grande for municipal supplies is being developed by Albuquerque and Santa Fe.

Wetland habitats within the Middle Rio Grande are either intermittent or perennial. Intermittent wetland areas receive water during spring runoff as floods withdraw leaving ponded backwaters which dry up with the hot summer sun. Perennial wetland areas include the Rio Grande riverside drains, low-flow conveyance channels and wetlands in the Belen, Bernardo, Casa Colorada, and La Joya State Waterfowl areas, and in the Sevilleta and Bosque del Apache National Wildlife areas. Oxbow lakes formed from cut-off channels of the Rio Grande also provide wetlands habitats.

The Lower Rio Grande

The Lower Rio Grande watershed (**WQCC 1975c**~~3~~) encompasses an area of approximately 5,000 square miles in parts of four counties including Catron, Socorro, Sierra and Doña Ana. The sub-basin is bound on the northwest by Socorro County's San Mateo Mountains with a peak elevation of 10,410 feet. The Mimbres Mountains extend north and south to the west of the Rio Grande in Sierra and Catron counties where the Continental Divide creates the western boundary. As these mountains recede, the boundary cuts east into Doña Ana County's Sierra de las Uvas near the Rio Grande and then south to the Mexican Border. It is near here where the basin's lowest elevation of approximately 3,800 feet is recorded. The eastern boundary of the Lower Rio Grande runs roughly parallel to the Rio Grande along the spine of the Organ and San Andres mountain ranges, about five to ten miles east of the river. The Lower Rio Grande is bordered on the east and west by vast expanses of desert and topographically closed basins, on the north by the Middle Rio Grande section, and on the south by the Republic of Mexico and Texas.

The Rio Grande bisects this section of the State from the headwaters of Elephant Butte Reservoir at the USGS gaging station near the old town of San Marcial to the point where it flows out of the State at the International Boundary and Water Commission sampling station above American Dam.

The Lower Rio Grande Sub-basin is dominated in the north by two large reservoirs, Elephant Butte and Caballo. These man-made reservoirs control and store the entire surface flow in this section of the Rio Grande Basin, thus providing two narrow fertile valleys, the Rincon and the Mesilla, with water for irrigation. Nearly all of the irrigated agricultural land in this watershed, about 100,000 acres, is to be found in these valleys along the river. The watercourse is tightly controlled and regulated southward as the Rio Grande is essentially channeled from Caballo Dam to the Texas/New Mexico State Line. It is confined to the pilot channel, with contiguous high water flood plains on either side of the channel, all contained between levees. The floodplain of the Rio Grande varies from less than one mile to five miles in width; and although there are numerous ephemeral tributaries running from the west down to the Rio Grande, there are no perennial streams or rivers within this section except the Rio Grande itself.

The climate of the entire area is essentially dry, with potential evapotransporation far exceeding precipitation levels annually. Yet, the Lower Rio Grande Valley consists of a narrow strip of green land with arid desert and semi-arid mountainous regions on both sides.

The channeled riverbed extends in a generally south and southeasterly direction through lands characterized by arid, gently sloping plains which are broken by barren mountain ranges and isolated mountain peaks. Approximately 80% of the Lower Rio Grande is between 4,000 and 6,000 feet in elevation and belongs in the lower Sonoran life zone. Except within the irrigated valleys, this entire area is characterized by creosote, tar bush and mesquite. The surrounding slopes of the San Mateo and Mimbres mountain ranges exhibit grasslands characteristic of the upper Sonoran. Woodland areas of the Transition zone denoted by areas of piñon, juniper, oak and mountain mahogany are found further up their slopes. Located highest of all are small pockets of northern coniferous forest, which is comprised of a spruce and fir biome.

Amounts of precipitation are sparse, but correspond closely to altitudes. Snowfall is generally light throughout the Lower Rio Grande. The dry seasons in this portion of the State occur in Fall, Winter and Spring mainly because of a rain shadow effect, a condition where moisture circulating eastward from the Pacific Ocean is removed as air masses pass over and rain on mountains west of the State. Summer in this portion of New Mexico is the rainy season, when southeasterly circulating moisture-laden air from the Gulf of Mexico enters the southern parts of the State and strong surface heating, aided by uplifting air flow, brings brief and often heavy showers. Average annual precipitation along this section of the Rio Grande Valley ranges from six to eight inches, while the high mountains to the west receive up to sixteen. Rainfall is highly variable, however, with annual local totals as low as three inches or as high as 19 inches, even at lower elevations.

Aquifers in the Lower Rio Grande may be generally separated into two groups, valley fill and bedrock. Ground water, primarily from the valley fill, is used for municipal, industrial, agricultural, rural domestic and livestock purposes. The Rio Grande, by means of the reservoir system, furnishes the primary supply of water for irrigation.

Surface Water Quality Concerns In The Rio Grande Basin

The Rio Grande Basin has a total of 1,202 State-jurisdictional miles of assessed river reaches that only partially or do not support their designated or attainable uses. The specific pollutants or threats in this lack of support are turbidity, stream bottom deposits, metals, pH, total ammonia temperature, pathogens, plant nutrients, and conductivity. The probable sources of this non- or partial-support are agriculture, recreation, hydromodification, road and highway maintenance, silviculture, resource extraction, municipal and domestic point sources, land disposal, road runoff, and natural and unknown sources. The most commonly found toxin in acute concentrations is aluminum, and the most commonly found toxins in chronic concentrations are aluminum, and selenium.

The Rio Grande Basin currently has at least 18,585 assessed lake acres that only partially or do not support their designated or attainable uses. The specific pollutant or possible threat in this lack of support are excessive nutrients, pH imbalance, low dissolved oxygen, presence of mercury in fish tissues, and nuisance algae and excessive temperature. The probable sources of these causes include agriculture, land disposal, off-road vehicle use, natural and unknown conditions, and recreationally-associated problems such as road /parking lot runoff and roadway maintenance.

Ground Water Quality Concerns In The Rio Grande Basin

~~Approximately 90% of the population of New Mexico depends on ground water for its domestic water supply. In New Mexico, at least 1,240 ground water contamination plumes emanating from point sources and numerous areas of widespread contamination from nonpoint sources have been identified from data acquired between 1927 and June 2001. This contamination has impacted at least 191 public and 1,721 private water-supply wells.~~

~~Approximately 12 % of all cases of ground water contamination in New Mexico have been shown to be caused by nonpoint sources, predominantly household septic tanks and cesspools which together create the single largest known source of ground water contamination in the State. It is estimated that there are over~~

~~180,000 household septic tanks or cesspools in the State discharging roughly 68 million gallons of wastewater every day. Other nonpoint sources which may impact ground water include residual minerals from evapotranspiration, pesticides and fertilizers from agricultural and urban sources, discharges from mine water and urban runoff.~~

Nonpoint Sources of Contamination

Nonpoint sources of ground water contamination in the Rio Grande Basin include predominantly private septic systems and agricultural facilities, mostly dairies that land-apply their effluent. Naturally occurring geologic deposits can also contribute to ground water contamination. The following nonpoint contaminants have been found to contribute to ground water pollution in the Rio Grande Basin:

Iron, Manganese and Sulfides

Anoxic contamination is a condition in which dissolved oxygen in ground water has been depleted. Iron, manganese and sulfides are typical ground water contaminants in areas exhibiting this condition. Anoxia can be caused by septic tank discharges or by naturally occurring geologic deposits such as humus or peat. Anoxic conditions are typically seen in shallow ground water in highly populated areas that use septic tanks or cesspools to treat sewage. Anoxic contamination has been reported throughout New Mexico with cases reported within the Rio Grande Basin occurring in Española, Pojoaque, Corrales, both the North and South Valleys of Albuquerque, Los Lunas, a large area in Bosque Farms, Belen, and Las Cruces**.** ~~involving at least 505 wells.~~

Arsenic

Naturally occurring concentrations of arsenic became a serious water quality problem in the Middle Rio Grande Basin when the EPA enacted a new more stringent drinking water standard. The more stringent federal standard of 10 μg/L will be extremely costly to the Citizens of New Mexico. Current capital outlay cost estimates range from \$250 million to excesses of \$500 million. Annual operating costs are estimated to be in the range of 2 – 5% of capital costs~~. Domestic water in the Village of San Ysidro has an average arsenic~~

~~content of about 170 µg/L. In addition, several~~**Many** communities, including Albuquerque have wells that violate the new 10 µg/L standard. ~~Compliance~~ **While compliance was** previously achieved either by blending source waters or by turning off affected wells**, this** will likely no longer suffice, and arsenic removal will be required.

Nitrates

Nitrate contamination of ground water is also found in areas where there is heavy loading by septic tanks and cesspools, but unlike areas with anoxic contamination, the vadose zone is sufficiently thick and aerobic for ammonia nitrification to occur. Nitrates typically do not cause aesthetic problems like anoxic conditions, but can be shown to cause various health problems, such as methemoglobinemia or "blue baby syndrome", a potentially serious and sometimes fatal disease affecting infants and their ability to absorb and release oxygen with their blood.

Nitrate contamination is prevalent in areas with high densities of septic tanks ~~and~~ **,**cesspools**, and dairies**. **In addition to nonpoint sources (for example, septic tanks or land application of dairy effluent),**~~Nitrate~~ **nitrate** contamination also can occur from point-sources such as meat packing and processing plants, sewage treatment plants, **dairy lagoons**~~dairies, feedlots~~, landfills, uranium mills, and explosives manufacturing or disposal facilities. Nitrate contamination has been reported in Questa, Taos, Española, Tesuque, Santa Fe, Grants, Bernalillo, Corrales, Albuquerque, Bosque Farms, Los Lunas, Belen, Anthony, Las Cruces**,** and **area between** Mesquite **and Vado (“dairy row”)**.

~~Albuquerque's South Valley Mountain View community contains a serious case of nitrate contamination caused by over-fertilization at a former vegetable farm. NMED, the University of New Mexico, the Bernalillo County Environmental Health Department, and the New Mexico Waste-management Education and Research Consortium (WERC), in a partnership, are developing a technology for *in-situ* biodenitrification using Mountain View as the prototype project site.~~

Pesticides

Pesticides such as insecticides, herbicides and fungicides have been used in New Mexico agriculture. Only 4 detections of pesticides in shallow agricultural and urban use aquifers were discovered out of an overall pool of 110 statewide sampling sites. All detections were well below established USEPA Health Advisory levels. Efforts by NMED and the New Mexico Department of Agriculture to monitor the use of such chemicals and their occurrence in ground water as a means of identifying and preventing future ground water contamination problems were concluded in 1999.

Total Dissolved Solids (TDS)

Residual minerals left behind by evapotranspiration (ET) can increase the levels of TDS in ground water and form alkali deposits in the soil. ET has degraded the quality of shallow ground water in vast areas of the Rio Grande Valley (**4WQCC 1992**).

Point Sources of Contamination

Point source contamination in the Rio Grande Basin is predominantly industrial in nature, involving refined petroleum in approximately half of the cases. Non-industrial point sources include centralized sewage-treatment works and landfills. Most of New Mexico's point source cases have resulted from either poor historical disposal practices, or accidental, permitted or unpermitted discharges. The following point sources have been found to contribute to ground water pollution in the Rio Grande Valley:

Leaking ~~Underground~~ Storage Tanks and Refined Petroleum Products

In the Rio Grande Basin there are approximately 1,269 sites as of November 1999 where leaking ~~underground~~ storage tanks have been reported. The majority of these reported ground water contamination cases are due to gasoline, jet fuel, diesel, gasoline additives, petroleum constituents such as benzene, toluene, ethyl benzene, and xylene. The bulk of these sites are concentrated around the major industrialized areas such as Albuquerque, Santa Fe and Las Cruces in areas typically associated with service stations, liquid petroleum storage and distribution centers and pipelines, and government facilities (**4WQCC 1992**).

Landfills

Many landfills in New Mexico have received large amounts of liquid and/or industrial wastes. Ground water contamination has been detected in three landfills in the Rio Grande Valley. These landfills are located in Albuquerque, Albuquerque's South Valley, and in Doña Ana County. Contaminants include chlorinated solvents and basic-, neutral- and acid-extractable compounds.

Radionuclides (RN)

Six cases of anthropogenic RN ground water contamination have been reported in and around the Department of Energy's Los Alamos National Laboratory facility.

Halogenated Aliphatic Compounds

There are also ground water contamination sites located in the Rio Grande Basin that involve halogenated aliphatic compounds, primarily solvents. Trichloroethylene (TCE) and other halogenated aliphatics have caused ground water contamination in Arroyo Hondo, Española, Santa Fe, San Rafael near Grants, Bernalillo, Albuquerque proper, Albuquerque's South Valley, Tijeras, Carnuel, Sedillo, Laguna Pueblo, Los Lunas, Belen, Socorro, Mesita, Organ and Las Cruces. Halogenated aliphatic compounds are used in various manufacturing processes, the dry cleaning industry, degreasing metals, and as fumigants (~~5~~**Merck & Cº. 1989**).

Polychlorinated Biphenyls (PCB's)

Formerly used as hydraulic fluids, plasticizers, adhesives and fire retardants, PCB's were used in electrical transformers and capacitors, vacuum pumps and gas-transmission turbines. Ground water contamination sites involving PCB presence are in Belen, Las Cruces and on Laguna Pueblo.

Total Dissolved Solids

Point source ground water contamination due to elevated levels of TDS is found near many of the mining and milling sites in New Mexico. Seboyeta, Milan, Bluewater and Grants were found to have high TDS in ground water due to uranium mining activities, Cuba from copper mining, and Questa from molybdenum mining activities. TDS also results from natural limestone deposits in these areas.

Metals

Metals such as aluminum, cadmium, cobalt, iron, lead (other than those associated with gasoline spills and LUSTS), manganese, selenium and zinc have been found to be the cause of several cases of ground water contamination throughout New Mexico. These cases, from both nonpoint and point pollution sources, are found in Medenales, Santa Fe, Golden, Corrales, Sedillo, Grants, Milan, Albuquerque, and Cuba.

~~Spills~~

~~A total of 299 spill cases are recorded on NMED's spill report database for the time period of January 2000 to June 2001. 99 of the total (43%) are located within the twelve counties that make up the Rio Grande Basin (Table 1). While many of these cases are not known to currently impact ground water, in some cases they may cause serious damage.~~

~~TABLE 1 Number of reported spills currently recorded in the Rio Grande Basin~~

~~Rio Arriba~~	~~0~~	~~Cibola~~	~~1~~
~~Taos~~	~~6~~	~~Bernalillo~~	~~24~~
~~Los Alamos~~	~~2~~	~~Valencia~~	~~8~~
~~Sandoval~~	~~5~~	~~Socorro~~	~~2~~
~~Santa Fe~~	~~17~~	~~Sierra~~	~~3~~
~~McKinley~~	~~9~~	~~Doña Ana~~	~~7~~

THE ARKANSAS/WHITE/RED RIVERS BASIN

The New Mexico portion of the Arkansas/White/Red Rivers Basin (**WQCC 1975a**~~6~~) is located in the northeast corner of the State. The area within the basin encompasses Union, Harding and Colfax counties, most of Mora and Quay counties, and part of San Miguel County. Also included are small parts of Curry and Guadalupe counties. The Arkansas/White/Red Rivers Basin in New Mexico is bounded on the north by the

State of Colorado, on the east by the States of Oklahoma and Texas, on the south by the Pecos River Basin and portions of the High Plains, and on the west by the Rio Grande Basin. The entire area covers approximately 17,066 square miles, or about 14% of the State's total geographical area.

The Arkansas/White/Red Rivers Basin exhibits diverse topographical characteristics. It is composed of grassy plains and arid valleys in the eastern section where elevations range from 3,600 feet in the south to 7,350 foot high Emory Peak in the north. The entire western side of the basin is bounded by the Sangre de Cristo Mountain Range with elevations as high as 13,161 feet.

The Arkansas/White/Red Rivers Basin in New Mexico is mostly drained by the Canadian River and its tributaries. The Canadian River flows southward from its headwaters near the Colorado/New Mexico State Line west of Raton, into southern San Miguel County, then eastward into Texas and its confluence with the Arkansas River. The Purgatoire River drains a small area of the land west of Raton north-eastward into the Arkansas River of Colorado. The other drainages flow eastward and southeastward into Oklahoma and Texas. Of the six sub-basins draining the area, only three, the Canadian River, the Dry Cimarron and Corrumpa Creek, are perennial. The Canadian River is now perennial throughout its entire length in New Mexico, in part due to discharges from Conchas and Ute reservoirs. Both the Dry Cimarron and Corrumpa Creek have perennial reaches near their headwaters but may, in dry years, show little or no surface flows throughout the majority of their drainages.

The major streams in the Canadian River Sub-basin are the Vermejo River, Mora River, Cimarron Creek (which drains from Eagle Nest Lake), Canadian River, Conchas River, and Ute Creek. The Canadian River flows 163 miles from its headwaters in the mountains west of Raton to Conchas Dam, 77 miles from Conchas Dam to Ute Reservoir, and about fifty miles from Ute Reservoir to the Texas state line. The Mora River, Cimarron Creek and the Vermejo River drain the eastern slopes of the Sangre de Cristo Mountains and are the Canadian River's major tributaries. Three significant reservoirs, Eagle Nest, Conchas, and Ute, are located within the basin.

The climate in the basin ranges from semi-arid in the lower elevations to subhumid in the timbered mountainous regions. Normally, the summers are hot and the winters are mild. Low humidity and clear skies prevail most of the year. There are large seasonal and diurnal fluctuations in temperatures which are typical of the higher elevations in the continental areas. Strong winds blow throughout this region especially during the spring and fall months. With few exceptions, more than fifty percent of the precipitation occurs between the months of May to September with the greatest amount occurring during July and August. Warm, moist air rising from the Gulf of Mexico provides most of this precipitation in the form of intense but brief afternoon thunderstorms throughout this late-summer period.

Surface Water Quality Concerns in the Arkansas/White/Red Rivers Basin

Surface water quality concerns in this Basin are largely limited to nonpoint source impacts. Among the most prevalent are the effects of historical grazing practices and, more recently, recreational impacts. A few point source concerns have been identified in the basin within the last few years.

The Arkansas/White/Red Rivers Basin has 427 State-jurisdictional miles of assessed river reaches that do not fully support their designated or attainable uses. The specific pollutants or threats in this lack of support are turbidity, stream bottom deposits, nutrients, metals, pathogens, temperature, and total dissolved solids.

The most probable sources for these causes are agriculture, resource extraction, recreation, hydro-modification, road runoff, silvicultural activities, road construction and municipal point sources and domestic point sources for the total ammonia, pathogens and nutrients. The most prevalent toxins, both of which are found in chronic levels are aluminum and lead.

The Arkansas/White/Red Rivers Basin has approximately 11,296 assessed lakes acres that do not fully support their designated or attainable uses. The most specific pollutant or perceived threat in this lack of support are , nutrients, siltation, pH,low dissolved oxygen, and mercury presence in fish tissue.

Probable sources of these causes are mainly grazing, roads, lack of lakeside vegetation and atmospheric deposition.

Ground Water Quality Concerns in the Arkansas/White/Red Rivers Basin

Most ground water availability problems presently encountered in the Arkansas/White/Red Rivers Basin are associated with agricultural demands. On the east side of the basin, near the Texas border, large amounts of ground water are used for irrigation. Lands irrigated by ground water are in Union and Harding counties and in Quay County north of Logan. Ground water is presently used by most communities for domestic uses and is also utilized by a few industries. However, urban or rural domestic, self-supplied industrial and recreational uses represent only a small fraction of the basin's present annual water use.

Currently, three significant sources of ground water contamination are from leaking underground storage tanks, septic systems, and grain silos that were fumigated with carbon tetrachloride in the Arkansas /White/Red Rivers Basin.

Leaking ~~Underground~~ Storage Tanks and Refined Petroleum Products

As of November 1999, about 126 leaking ~~underground~~ storage tank sites were reported in the Arkansas/White/Red Rivers Basin. The majority of these reported ground water contamination cases are due to oil, gasoline, jet fuel, diesel, gasoline additives, petroleum constituents such as benzene, toluene, ethyl benzene, and xylene, and solvents such as chlorinated methane, ethanes, propanes and ethylenes. The bulk of these sites are concentrated around the municipal and industrialized areas such as Raton, Springer, Angel Fire and Maxwell in Colfax County, and Tucumcari in Quay County. These areas are typically associated with service stations, liquid petroleum storage and distribution centers, and pipelines, or other extractive activities.

Nitrates

Nitrate contamination is prevalent in areas in the Arkansas/White/Red Rivers Basin where there are high densities of septic tanks and cesspools. Nitrate contamination also occurs from meat packing and processing plants, sewage treatment plants, dairies and feedlots. Nitrate contamination has been reported in

Maxwell, Angel Fire, Wagon Mound, Solano, Tucumcari, Logan, and San Jon.

Halogenated Aliphatic Compounds

Halogenated aliphatic compounds have been detected in ground water in Tucumcari and in Texico. Grain fumigants and degreasing solvents are the suspected sources.

THE CENTRAL CLOSED BASINS

The Central Closed Basins (~~7~~**WQCC 1975b**) are a cluster of four drainage systems in the south-central part of New Mexico. These basins total 14,605 square miles and include portions of eleven counties: Santa Fe, San Miguel, Bernalillo, Torrance, Socorro, Lincoln, Sierra, Otero, Doña Ana, Chavez and Eddy. Each basin completely contains all the surface flows within its boundaries. Little of this flow is perennial; the names of two of the basins give an indication of the lack of surface water within their boundaries: Jornada del Muerto (*Journey of Death*) and the Salt Sub-basin. While the other two basins, the Tularosa and the Estancia, likewise exhibit limited surface water, they support the bulk of the region's population with substantial ground water resources.

Because of the geologic history of the Central Closed Basins, the quantity and quality of the ground waters vary tremendously. Ancient lakes and streams deposited waterbearing fill over older bedrock. Cracks and fissures in the bedrock of Permian and Pennsylvanian ages yield small quantities of relatively good quality water. However, the yield of the Yeso Formation is highly saline. The overlying valley alluvium generally consists of unconsolidated gravels, sands, and clays capable in some areas of yields up to 2,000 gallons a minute. Potable water is mostly found from wells near the edges of the basins with more saline water toward the basin centers.

One geologic formation deserving special mention is the Madera Limestone of the Manzano Mountains at the northern end of the Basin. This Pennsylvanian Age aquifer is important despite its small yield (ten gallons a minute), as it is the only source of potable water in the area. Thus, despite its proximity to Albuquerque, the Manzano Mountains may experience only limited development because of such a low yield unless regional water supplies are developed.

The largest water withdrawal in the Central Closed Basins is in the Estancia Sub-basin, where the water is primarily used for irrigated agriculture. The economy of the basin depends to a great extent on irrigated agriculture. Usage of these ground water resources in the 1930s enabled agriculture to expand rapidly in the area. Most of the irrigation is in the lower, more frost-free parts of the Estancia and Salt sub-basins and is dependent on ground water, although the Rio Tularosa and a few other perennial streams in higher altitudes provide water for about ten percent of the irrigated acres in the two basins.

The Estancia Sub-basin has no perennial streams, although playa lakes such as the Laguna del Perro often contain some water. The major source of domestic water supplies in this area is the alluvium; but the Madera Limestone in the west, the Glorieta Sandstone in the north, and the Yeso formation in the southern and northeastern parts of the valley also yield considerable water.

The Tularosa Sub-basin exhibits the next largest water use in the Central Closed Basins, with water use in the Jornada del Muerto and Salt sub-basins being considerably smaller. The upper reaches of Three Rivers and of the Sacramento River are perennial in the Tularosa Sub-basin. However, water used for domestic supplies generally comes from the ground waters; the largest exception is that portion of Alamogordo's water supplied from Lake Bonito (which is in the Pecos River Basin). Ground water in the Tularosa Sub-basin is located in a large alluvial deposit with very little fresh water. There are a few scattered locations around the edges of the basin where fresh water is available, but only two of these are principal water sources. One consists of a long narrow area around Tularosa and Alamogordo; the other more productive area is in the southwestern part of the basin.

There are only ephemeral surface streams in the Jornada del Muerto Sub-basin. Ground water exists in sufficient quantity throughout the basin at depths ranging from 30 to about 400 feet for watering of livestock. Most of this ground water is slightly saline and therefore contains concentrations of dissolved solids that are higher than recommended levels for human consumption. In rare locations, sufficient water for irrigation has been developed from the Dakota Sandstone deposits and its underlying San Andres formation, but this water is slightly brackish. The few known sources of fresh water in the Jornada del Muerto are found around the edges of the basin in alluvial fan deposits.

The only perennial flow of consequence in the Salt Sub-basin is in the upper reaches of the Sacramento River at the northern end of the basin. The Bolson alluvium produces about 840 gallons of water per minute. Ground water in large quantities suitable for irrigation is obtained west of the alkali flat that occupies the central part of the basin. The Bone Spring Limestone formation is a prolific bedrock aquifer penetrated by many irrigation wells, and has yields measured as high as 3,620 gallons per minute with only ten feet of head pressure. However, rough estimates suggest fresh water storage of only about a half-million acre-feet in the Salt Sub-basin as a whole.

The climate of the Central Closed Basins, like most of New Mexico, varies with elevation. The lower areas of each basin are warm and dry, being around 4,000 feet in elevation. Potential evapotranspiration in these areas significantly exceeds annual precipitation. The mountainous rims of the four basins, in contrast, have a cooler and more humid climate, often with fewer than one hundred frost-free days and more than twenty-five inches of rainfall in an average year. The edges of these basins are generally at least 6,500 feet high while Sierra Blanca, on the rim of the Tularosa Sub-basin, is over 12,000 feet in elevation. Wind patterns in the lowlands combine with sparse vegetation in these areas to cause localized cyclones, or "dust devils," with heights up to 12,000 feet.

The varieties of climates and topographies have fostered an equally disparate economic base. Although parts of the Central Closed Basins have been continuously inhabited for thousands of years, the lack of perennial surface water flow in most areas inhibited settlement until recently. Sparse population and large open areas attracted the United States Department of Defense to acquire about one-third of the basins' total land for weapons and rocket experimentation. White Sands Missile Range, Holloman Air Force Base, and Fort Bliss Military Reservation cover most of the southwestern part of the Tularosa Sub-basin. The mountainous areas east of Alamogordo along with the Manzano and Sandia mountains east of Albuquerque are experiencing considerable tourist, second home, and recreational development, while the area in and around Cloudcroft has been one of the faster growing areas in the State.

The overall limiting factor to growth and development in the Central Closed Basins, besides the absolute availability of useable water, is the high rates of evaporation which limit the use of existing supplies for agriculture. There are areas throughout these sub-basins with suitable soils for irrigated agriculture yet are not under cultivation because of the lack of adequate, high quality water.

Surface Water Quality Concerns in the Central Closed Basin

The Central Closed Basin has 16.2 State-jurisdictional assessed river miles that are listed as only partially supporting their designated uses. The specific pollutants or threats in this lack of support are temperature, and conductivity. The recognized probable sources of this lack of support are traditional rangeland practices, removal of riparian vegetation streambank modification/destabilization and other unknowns as well as overall watershed condition.

Ground Water Quality Concerns in the Central Closed Basin

In the Central Closed Basin the greatest sources of ground water contamination are from leaking ~~underground~~ storage tanks and septage systems.

Leaking ~~Underground~~ Storage Tanks and Refined Petroleum Products

As of November 1999, there were approximately 126 leaking ~~underground~~ storage tank sites reported in the Central Closed Basin. The majority of these reported ground water contamination cases were due to gasoline, jet fuel, diesel and gasoline additives. The bulk of these sites are concentrated around the municipal and industrialized areas such as Alamogordo in Otero County and Moriarty, Encino and Estancia in Torrance County. These areas are typically associated with service stations, liquid petroleum storage and distribution centers, pipelines, and the military installations at Fort Bliss, Holloman AFB and the White Sands Missile Range.

Nitrates

The incidences of nitrate contamination are found mostly in the Central Closed Basins Estancia Valley and in and around the City of Alamogordo. This problem is mostly due to high densities of septic tanks and cesspools found in the populated areas.

THE LOWER COLORADO RIVER BASIN

The Lower Colorado River Basin (**WQCC 1974a~~8~~**) in New Mexico consists of a number of tributary drainages that start in or near New Mexico and continue into Arizona. Included in this basin are portions of McKinley, Cibola, Catron, Sierra, Grant, Luna and Hidalgo counties. While several streams rise in New Mexico and join larger tributaries of the Colorado River in Arizona, only one stream, the Gila River, originates in New Mexico and directly joins the Colorado itself.

Included in the discussion of the Lower Colorado River Basin boundaries is the Animas Closed Sub-basin of New Mexico. The Animas Sub-basin, approximately 2,400 square miles in area, is one distinct hydrologic unit, and just one of several closed basins to the south and east of the Lower Colorado Basin.

The following is a description of the five sub-basins within the Lower Colorado of New Mexico, starting from the furthest north.

The Little Colorado River Sub-basin in New Mexico has an area of some 5,150 square miles, which includes three principal streams systems: the Puerco River (Rio Puerco of the West), the Zuni River and Carrizo Creek. The sub-basin also includes several minor drainage systems. Only the Zuni is a perennial stream, and then only in its upper reaches. It is formed by the junction of the Rio Nutria and Rio Pescado, both of which rise on the forested western slopes of the Zuni Mountains. Much of the sub-basin is subject to severe sheet erosion and head-cutting.

This sub-basin is primarily within the Navajo Section of the Colorado Plateaus physiographic province. The Navajo Section is considered young plateau country characterized by relatively low relief. Elevations generally range from about 6,000 to 7,500 feet above mean sea level, but in places reach 9,000 feet.

The drainages are not deeply entrenched, and canyons more than a few hundred feet deep are uncommon. Although the relief is not great, the topography is rough. Wide flat-bottomed washes bordered by cliffs of sandstone from 10 to 200 feet high rise step-like to flat-topped table lands and are the most conspicuous features of much of the region. Dissection of the broad Zuni uplift east and southeast of Gallup has produced a locally mountainous terrain. Young lava flows that fill some of the wide shallow valleys mark the transition zone between the Navajo Section and the Datil Section to the south.

The next sub-basin includes the <u>San Francisco River</u> drainage which arises in Arizona, enters New Mexico west of Luna, and returns to Arizona southwest of Glenwood, New Mexico, where it joins the Gila River near Clifton, Arizona. The San Francisco Sub-basin in New Mexico has an area of 1,900 square miles. The San Francisco River is perennial throughout most of its course in New Mexico, but the channel is sometimes dry in the reach immediately above Glenwood. In that area, the valley is wide, the channel fill relatively thick, and water disappears into the gravel only to reappear downstream. The river receives the flow of several perennial tributaries that rise in the Mogollon and Tularosa mountains on the east side of the basin, and in the San Francisco Mountains and Blue Range to the west. The main perennial tributaries are Tularosa River, Negrito Creek, Whitewater Creek, Apache Creek, and Saliz Creek. Jenkins Creek, Pueblo Creek, and Mule Creek drain a large area and have perennial flow in the upper part of their courses; they may contribute appreciable underflow to the San Francisco River through channel gravels in their reaches.

The <u>Gila River</u> originates in a wilderness area between the Mogollon Mountains and the Black Range, then flows in a southwesterly direction for about 100 miles before entering Arizona near Virden. Elevations vary from 10,800-foot Mogollon Peak to 4,000 feet near Virden. In general, this sub-basin is mountainous with streams enclosed in long narrow valleys. The Gila Sub-basin of New Mexico has an area of 3,500 square miles. The river normally is perennial from its source in the Gila Wilderness to the New Mexico/Arizona State Line, but diversions for irrigation result in stretches of the river being dry at times. The Gila River receives water from numerous small perennial creeks in the high country, the principal ones being Willow, Beaver, Taylor, and Sapillo creeks. The Mogollon, Bear, Duck, Mangas, and Blue creeks typically discharge their waters into the Gila by underflow through channel gravels.

Most of the Gila Sub-basin lies within the Colorado Plateaus physiographic province. However, the southernmost New Mexico reaches of the river are entrenched in the aggraded desert plains of the Mexican Highlands. This section is typified by generally low relief. However, the Gila River has cut sharply 300 to 500 feet into the plains and has developed a flat-bottomed inner valley up to a mile wide in the vicinity of Virden and Red Rock. Tributaries to the south have also cut well-defined channels for a few miles.

San Simon Creek Sub-basin has an area of 220 square miles in New Mexico. San Simon Creek, which joins the Gila River in Arizona is not perennial and has no tributaries of consequence in New Mexico. Flood flow from the western slopes of the Peloncillo Mountains in New Mexico occasionally may reach the main channel. Tributaries, principally Cave Creek, which rise in the Chiricahua Mountains in Arizona, may contribute some underflow to the San Simon Valley. Characteristics of the basin resemble those of the adjacent topographically closed basins to the east, such as the Animas, more closely than those of the rest of the Lower Colorado Basin.

In the Animas Closed Basin, runoff collects in the upper valley of Animas Creek and spreads northward across the lower valley in a wide indistinct channel which terminates in broad playas at the north end of the basin. Areas around Lordsburg in particular are irrigated with ground water.

Surface Water Quality Concerns in the Lower Colorado River Basin

The Lower Colorado Basin has 517 State-jurisdictional assessed river miles that are listed as only partially or not supporting their designated uses. The Basin also has approximately 206 assessed lake acres that are listed as only partially or not supporting their designated uses.

Water quality management of the Lower Colorado Basin has gone through significant and important changes in the past few decades, as increasing knowledge of environmental pollution factors has grown. Although water quality problems remain relatively few when compared to more populated regions of the

State, the basin can exhibit some of the same controversial and complicated contamination situations typically found elsewhere.

In the Gila/San Francisco system the most common mode of metal transport is associated with the suspended component. The less common, but biologically more damaging mode of transport, are those releases in which the metals are in the dissolved phase. This occurs in areas where mining wastes are high in sulfides. The common pH range in such situations is from 2.0 to 5.0 with metal loading varying from small traces to extremely high values.

Additional water quality concerns seen throughout the sub-basins are the historical degradation of the riparian community, habitat alteration, and the resulting destabilization of streambanks caused by overgrazing, low dissolved oxygen, stream bottom deposits, temperature, turbidity and forest management such as fire suppression. Other concerns include the presence of pathogens, sediment-laden runoff from forest roads and recreational impacts caused by off road vehicles, camping and streamside trails, hydromodification and silviculture projects as well as nutrient-enriched waters. The specific pollutant or threat of partial or non-support of lake acres in the Lower Colorado River Basin include excessive nutrients, nuisance algae, siltation, and high temperature. Probable sources of these causes include silviculture, recreation, road maintenance, grazing and overall watershed condition.

Ground Water Concerns in the Lower Colorado River Basin

The majority of the ground water concerns in the Lower Colorado River Basin are from leaking ~~underground~~ storage tanks and refineries, nitrates from septic tanks, cesspools and public and privately owned sewage treatment plants, cyanide, metals and total dissolved solids from mineral leaching operations, and total dissolved solids, metals and sulfates from past uranium milling operations.

Leaking ~~Underground~~ Storage Tanks and Refined Petroleum Products

In the Lower Colorado River Basin there were approximately 133 sites where leaking ~~underground~~ storage tanks had been reported as of November 1999. The majority of these reported ground water contamination cases were due to gas, oil, diesel and gasoline additives. These areas are typically associated with service stations, liquid petroleum storage and distribution centers and the bulk of these sites are concentrated around municipal, industrialized centers, and mining operations in and around the City of Gallup in McKinley County and Apache Creek, Reserve, and Quemado in Catron County.

Nitrates

Nitrate contamination areas in the Lower Colorado Basin are mostly found around Lordsburg in Hidalgo County and are mostly associated with high densities of septic tanks and cesspools and publicly owned sewage treatment plants.

Salinity

Salinity problems in the Lower Colorado River Basin have been addressed by the New Mexico Interstate Stream Commission. New Mexico participated with other western states in establishing the Yuma Desalting Project which was created to remove salinity from the basin waters that are eventually used by Mexico (**State Engineer Office 1995**~~9~~).

THE PECOS RIVER BASIN

Originating high in the Sangre de Cristo Mountains in north-central New Mexico where it is fed by snowmelt and rainfall, the Pecos River (~~10~~**WQCC 1976b**) flows southward through New Mexico for 435 miles and enters Texas south of Malaga. The Pecos River Basin of New Mexico encompasses an area of 25,992 square miles in fourteen counties, including Mora, San Miguel, Santa Fe, Guadalupe, Torrance, Quay, Curry, De Baca, Roosevelt, Chavez, Lincoln, Otero, Eddy, and Lea.

Major tributaries in the upper basin are Cow Creek, the Gallinas River, Tecolote Creek, Canyon Blanco, Pintada Arroyo, and Alamogordo Creek. Between Sumner Lake and Carlsbad, the most important tributaries arise from the Sacramento Mountains in southcentral New Mexico. These streams include Rio Hondo, Rio Felix, Rio Peñasco, and Seven Rivers. In the Carlsbad area of Eddy County the principal drainage courses are Dark Canyon, Black River, and the Delaware River.

The geology of the basin is highly variable with rock outcroppings ranging in age from Precambrian to Recent. Sedimentary rocks underlie most of the basin with igneous rocks appearing most numerous in the western part of the basin. The igneous rocks of the mountains are not, as a rule, waterbearing. Most of the waterbearing rock formations in the Pecos\ River Basin are sedimentary and found in the plains areas. The largest of these is the San Andres Formation, containing the Roswell-Artesian aquifer, which also supplies by seepage a considerable proportion of the water in the shallow alluvium aquifer above it.

Variation of flow in places along the Pecos River is partially controlled by the geology of the basin. For example, near the village of Colonias, about fifteen miles upstream of Santa Rosa, the Pecos River channel is often completely dry; the flow remaining in the river below irrigation diversions seeps into the permeable San Andres Formation.

The Pecos River and Rio Hondo are regulated by Sumner Lake, Two Rivers, and Brantley Reservoirs. These were built primarily for flood control, irrigation purposes, recreation, and sediment retention. There are other smaller reservoirs in the basin which are used to control sediment and runoff.

Because the principal determining factor is the gradual downgrade of the land from the northwest to the southeast, the climate in the Pecos River Basin is moderate in temperature and relatively sub-humid to semi-arid. The northern portions of the basin have greater rainfall and lower evapotranspiration rates and are cooler. Rapid diurnal temperature fluctuations occur because of the predominantly clear and dry atmospheric conditions. Usually November and February are the driest months of the year, whereas July and August are the wettest. The basin's precipitation varies from approximately 12 inches in the southern portions to 35 inches in the northern mountain areas. The average growing season in the upper basin (above Pecos, New Mexico) is less than a hundred days while in the lower basin it is over 200 days.

Water quality management in the Pecos River Basin has long been recognized as a necessary and significant contribution to insuring sustainable human activity within this area of the Southwest. As early as 1942, the National Resources Planning Board stated

"...For its size, the basin of the Pecos River probably presents a greater aggregation of problems associated with land and water use than any other irrigated basin in the Western U.S."

Some modern-day problems can still trace their origins even further back in time. The following subsection describes such a situation in the upper reaches of the Pecos River, not far from its headwaters.

Surface Water Quality Concerns in the Pecos River Basin

Willow Creek originates in the Pecos Wilderness west of Elk Mountain. This first-order tributary of the Pecos River remains healthy and highly productive for most of its length. However, less than a half-mile from its mouth on the Pecos River, this stream encounters the abandoned Pecos Mine, also known as the Terrero Mine.

Records show the site yielded 2,223,552 tons of raw ore, mostly made up of zinc and lead sulfides. The discarded sulfide wastes were disposed of in such a way that surface runoff from above the site infiltrates into the 19-acre waste rock pile and emerges at the base of the dump as an acidic metal-loaded drainage. It is suspected that runoff from the mine site contributed to periodic fish kills at the Lisboa Springs Hatchery, and potentially affected fish populations in the intervening reach of the Pecos River.

Mine waste was used throughout the upper Pecos River Canyon for fill material and road surfacing. Initial remedial actions have been implemented and accomplished at the mine site . The State Recreation Use Areas consist of campgrounds, day use areas and river access points managed by the New Mexico Department of Game and Fish (DGF). Remediation of this operable unit was completed in 1994. Remediation consisted of removing mine waste-contaminated soils with lead levels greater than 500 ppm and transporting them to a disposal cell at the mine site. A background report has been prepared for the Lisboa Springs Fish Hatchery, which includes Monastery Lake, that summarizes existing data and indicates areas needing additional investigation. A remedial investigation will be conducted to gather additional data, which will be used to formulate a longterm remedial solution.

The Pecos River Basin has 581 river miles that are listed as partially supportive or nonsupportive of their designated use. The specific pollutants or perceived threats in this lack of support include metals, turbidity, nutrients, pathogens, dissolved oxygen, stream bottom deposits and total ammonia from municipal point sources, temperature, and conductivity. The probable sources of these pollutants are road maintenance, construction, recreation, land disposal, resource extraction, agriculture, hydromodification, point sources, silviculture, unauthorized spills, road runoff, land disposal, and unknown and natural sources. Elevated conductivity also results from natural limestone deposits in this area. The toxic contaminant aluminum, has have been found at both acute and chronic levels.

The Pecos River Basin has 11,060 assessed lake acres that are listed as partially or not supporting their designated uses. The specific pollutant or threat in this lack of support include excessive nutrients, nuisance algae, siltation, and mercury in fish tissue . Probable sources of these causes include recreation, grazing, hydromodification, atmospheric deposition, and overall watershed condition.

Ground Water Quality Concerns in the Pecos River Basin

The main sources of ground water contamination in the Pecos River Valley are from leaking underground and above-ground storage tanks, mining and milling operations, manufacturing facilities, dairies, private and public sewage treatment plants, septic tanks and cesspools, as well as oil and gas production and refining operations.

Leaking ~~Underground~~ Storage Tanks and Refined Petroleum Products

The Pecos River Basin contains approximately 290 sites where leaking underground storage sites had been reported as of November 1999. The majority of these reported ground water contamination cases were due to gasoline, waste oil, diesel, gasoline additives, petroleum constituents such as benzene, toluene, ethyl benzene, and xylene and solvents such as chlorinated methane, ethanes, propanes and ethylenes. The bulk of these sites are concentrated around the major industrialized areas such as Santa Rosa in Guadalupe

County, Fort Sumner in De Baca County, Roswell in Chavez County, Atresia and Carlsbad in Eddy County, and Ruidoso, Alto and Carrizozo in Lincoln County. These contamination sites are typically associated with service stations, liquid petroleum storage and distribution centers, pipelines, and oil extraction operations.

Total Dissolved Solids

Point source ground water contamination due to TDS is found near many of the mining and milling sites in the Pecos River Basin.

Nitrates

Nitrate contamination is prevalent in areas where there are high densities of septic tanks and cess-pools. High nitrate concentrations can also be seen around meatpacking and processing plants, sewage treatment plants or dairy operations where large amounts of wastes saturate the ground. Nitrate contamination in the Pecos River Basin has been reported in Las Vegas, Los Montoyas, Ribera, Ruidoso, Hondo, Roswell, Dexter, Hagerman, and Carlsbad.

Halogenated Aliphatic Compounds

There are also ground water contamination sites located in the Pecos River Basin that involve solvent contamination. TCE and other types of solvents caused ground water contamination cases have been reported in Roswell and Carrizozo. Halogenated aliphatic compounds are used in some manufacturing processes, the dry cleaning industry and for degreasing metals (~~5~~**Merck & Cº. 1989**).

THE SAN JUAN RIVER BASIN

The San Juan River (~~11~~**WQCC 1976c**) is a major tributary of the Colorado River. Arising on the western slope of the Continental Divide in southwestern Colorado, the San Juan River flows from the San Juan Mountains north of Pagosa Springs, Colorado, and enters the extreme northwestern section of New Mexico via Navajo Reservoir in Rio Arriba County to the west of the Jicarilla Apache Reservation and the Carson National Forest. The course of the San Juan River in New Mexico turns westward for some 140 miles before the river turns back north and re-enters Colorado just a few miles to the east of the cartographic landmark known as "Four Corners." The San Juan River then resumes its westerly direction across Southern Utah towards its confluence with the Colorado River.

The San Juan River Basin in New Mexico includes lands from four counties. It encompasses all of San Juan County, most of the northern half of McKinley and western half of Rio Arriba counties, while taking up a relatively small corner of Sandoval County. Parts of the Navajo, Ute Mountain and Jicarilla Apache reservations are in the basin.

The San Juan River portion of the Upper Colorado Basin in New Mexico covers approximately 9,725 square miles, or 25%, of the total Upper Colorado drainage and consists of two sub-basins, those of the San Juan River and Navajo River. Water used in the basin largely comes from surface water sources. Ground water is used for domestic purposes and livestock watering. Irrigated agriculture predominately uses surface water withdrawals. Losses from power production and reservoir evaporation also affect the surface water supply.

A number of tributaries arise in southern Colorado to flow south toward their confluences with the San Juan River in New Mexico. These major tributaries are the Los Piños, Animas, La Plata, and Mancos rivers. The Navajo River also begins in southern Colorado, enters New Mexico and drains an area of 245 square miles, then turns north near Dulce where it is joined by the Amargo River, and re-enters Colorado, discharging into the San Juan River near Juanita. The length of the Navajo River in New Mexico is less than fifteen miles, with only the eastern portion within State jurisdiction (the remainder is within the Jicarilla Apache Reservation). Several tributaries of the San Juan River originate in New Mexico including La Jara Creek, Gobernador Canyon, Canyon Largo, and Chaco Wash, all of which are ephemeral watercourses.

The Colorado Plateau physiographic region extends into the northwestern section of the State of New Mexico, and this plateau region comprises the major portion of the San Juan River Basin of New Mexico. The area is generally one of horizontal sedimentary rocks carved into a gentle relief of broad mesas and valleys, buttes, plateaus, and canyons. The area is termed the <u>Navajo and Canyon Lands</u> section of the Colorado Plateau province.

The New Mexico portion of the San Juan River Basin is delineated on the north by the New Mexico/Colorado State Line and on the west as the New Mexico/Arizona state line. The southwestern edge of the basin is delineated by the peaks of the Chuska Mountains, which gradually rise to the Continental Divide at the southernmost tip of the basin. The Divide also gives the basin its eastern limits as it extends northward into Colorado.

The basin gradient extends generally westward from the point where the San Juan River flows from Colorado into New Mexico at an elevation of about 6,600 feet. The elevation of the river at Farmington is about 5,500 feet and at the point near Four Corners where the river leaves New Mexico and returns to Colorado the elevation is about 4,800 feet. The botanical species within the basin correspond to changes in elevation. The floor of the San Juan River Valley was originally populated by grasses, but these have mostly been replaced with irrigated croplands. The intermediate broad mesas are now predominately vegetated by grasses, sagebrush, pygmy piñon and junipers. Ultimately, the higher elevations are populated by stands of pine, fir and spruce.

The major portion of the San Juan River Basin consists of broad expanses of grassland and piñon-juniper stands, with an average mild continental climate which lacks extremes in hot or cold conditions. With precipitation under ten inches per year, this zone is principally arid, although rainfall is sufficient for some grasses, but not for dryland farming. The zone can be subdivided into an upper region of piñon/juniper forest where rainfall generally increases with increasing elevation. The lower, more open and arid valley bottoms constitute an area marked by a paucity of trees except along streams and by the scattered grasses, cacti, yuccas, and low desert shrubs.

The lower zone includes an extensive area drained by the San Juan River and its tributaries. This area is characteristically a great open plain with narrow bordering patches of piñon/juniper and scrub oak along the margins of surrounding foothills. This extensive valley bottom is also a region of deep erosion, comprising many canyons, dry washes, picturesque badlands, rich coal fields, and plentiful fossil beds.

The Chuska Mountains rise along the southwest corner of the basin to between 8,000 and 9,000 feet, and are actually a long mesa or plateau. Most of this table land is of sandstone, with abrupt rim rock margins and ridges of lava and basalt in the northernmost sections.

The summits of the Chuska Mountains are surrounded by forests and shallow lakes, usually without outlets. Many springs and short creeks rise in the canyons below the rim, flowing for short distances down steep slopes or in a few instances out into the nearby valleys. Water is abundant for stock but little is available for irrigation purposes. The vegetation ranges from open forests of ponderosa pine with grasses and shrubs to the colder, upper slopes covered with aspens, firs and spruces. Precipitation in this area progresses from 12 to 16 inches annually with increases in elevation. The eastern reaches of the basin beyond the vast expanses of grasslands, which constitutes the majority of the basin, consists of large stands of piñon/juniper forest gradually changing with increasing elevation into pine forests. Precipitation along the eastern reaches of the basin increases with altitude, from 10 to 18 inches on the average, annually.

The major portion of the San Juan River Basin of New Mexico receives 10 inches or less of average precipitation annually, and is therefore classified as arid. The areas of the basin where rainfall ranges from 10 to 16 inches is classified as semi-arid, although this classification should not be rigidly fixed where stands of piñon/juniper dominate. As the elevation increases towards the periphery of the basin, precipitation increases concomitantly so that above 5,900 and up to 7,200 feet the semi-arid zone is usually prevalent, beyond which the climate becomes more humid and cooler. Below 6,900 feet precipitation is generally too sparse for the maturing of crops, while in the moist zone of the higher elevations the growing season is too short.

The San Juan River Basin is geologically a structural as well as a topographic and hydrologic basin. Deposition of sediments of marine and continental origins, which commenced in early Paleozoic time, has continued in the basin with just a few intermittent interruptions. Sedimentary rocks in the central basin are at least 15,000 feet deep.

The San Juan structural basin extends into southwestern Colorado some 25 miles and slightly into Arizona. The structural basin boundaries are delineated on the east by the Nacimiento and southern San Juan mountains, on the south by the Zuni Mountains, on the west by the Defiance uplift and the Chuska and Carrizo mountains, and on the north by the Ute, La Playa, and northern San Juan Mountains.

Alluvium of recent age is found in and along channels of the principal streams and their tributaries and consist primarily of stream deposits and terrace gravel, both largely floodwash residuals. The San Juan River and other major streams of the basin are actively downcutting their channels, which are kept relatively free of thick accumulations of sediment through the action of flood flow and normal streamflow.

Three soil types predominate in the New Mexico portion of the San Juan Basin. Most of the area south of the San Juan River consists of a medium-textured, moderately deep to shallow soil that mantles gently rolling topography. Along the San Juan River and its northern tributaries, a medium- to heavily-textured deep soil is found which is suitable for agriculture. In the mountainous terrain of the northeastern part of the basin, shallow to moderately-deep soils with light to medium textures dominate.

The San Juan River Basin has been associated with energy production and its concomitant environmental pollution problems for the better part of the 20th century. The first oil-and-gas well was drilled near Farmington in 1900. The coal mining industry was started in 1911. Commercial petroleum fuel production was first organized in the 1920s. It was not until the 1950s that the fuel industry boom became a major force in the growth and development of the basin's economy, however, it remains a major economic factor in the Four Corners region today.

Surface Water Quality Concerns in the San Juan River Basin

The New Mexico Oil Conservation Division (OCD) and the United States Bureau of Land Management (BLM) are involved with energy development and associated environmental issues within the San Juan Basin (**Bureau of Land Management 1993~~12~~**). One emerging water quality concern affecting threatened and endangered fish in the region are their vulnerability to Polycyclic Aromatic Hydrocarbons (PAH). BLM, in consultation the State's OCD and NMED as well as other United States Department of the Interior agencies including the Fish and Wildlife Service, Bureau of Reclamation, Bureau of Indian Affairs and USGS, has developed a monitoring plan for the basin aimed at verifying alleged PAH contamination from the oil and gas industry. The monitoring project attempts to identify any possible PAH contamination sources. The plan is part of the BLM's Riparian Program, and was implemented in 1994.

Another aspect of the Riparian Program is weed control. The use of herbicides in the oil fields are closely monitored using criteria developed through the use of *DRASTIC* indexing. *DRASTIC* is a risk assessment modeling program for evaluating potential ground water pollution which features a numerical rating system developed by EPA. The acronym stands for *D*epth to water; (net aquifer) *R*echarge; *A*quifer media; *S*oil media; *T*opography; *I*mpact on the vadose zone media; and *C*onductivity. Applicators are limited to sixteen herbicides, and are limited to their area of use by *DRASTIC*'s parameters.

BLM's Riparian Program has also created a demonstration project of its implementation efforts in the Pump Canyon watershed. This relatively large block of public land is drained by an ephemeral tributary to the San Juan River. Their confluence is located approximately eight miles downstream from Navajo Reservoir Dam. The watershed is part of the Fruitland Coal Seam Development Area which has sustained heavy industrialized changes in the recent past including considerable road, pipeline, and facility construction. One goal of the project includes improving water quality and vegetative diversity through development and implementation of best management practices on existing uses. Accomplishments in the watershed have included initiation of surface water monitoring, several dozen acres of salt cedar treatment, riparian plantings, creating riparian fencing, implementing a moratorium on livestock grazing, developing 150-acre upland vegetative treatment project, and overseeing gas development mitigation efforts.

In the San Juan River Basin there are 135 assessed river miles that are listed as non- or partially-supporting their designated uses. The specific pollutant or threat in this lack of support include turbidity, nutrients, pathogens, temperature, and stream bottom deposits. Among the probable sources for these causes are resource extraction, hydromodification, agriculture, removal of riparian vegetation, streambank destabilization and overall watershed condition. There are no toxins listed at acute levels in the San Juan River Basin. . The U.S. Bureau of Reclamation is implementing a salinity control project on the Hammond Project near Bloomfield (**Office of the State Engineer 1998**~~13~~). The San Juan River downstream of the Hammond Diversion is the only stream in New Mexico currently listed in the State's **Fish Consumption Guidelines** (Appendix C) due to elevated mercury levels in fish.

The San Juan River Basin has 3,349 assessed lake acres that are listed as only partially supporting their designated uses. The specific pollutant or perceived threat in this lack of support is attributed to mercury in fish tissue. The probable source of this cause is currently unknown. Mercury levels in fish tissue are thought to be due to atmospheric deposition.

Ground Water Quality Concerns in the San Juan River Basin

The majority of ground water concerns in the San Juan River Basin are releases from leaking ~~underground and above ground~~ storage tanks, and from oil and gas production, pipelines, storage, distribution and refining sites. There are two reported cases of ground water contamination from landfills in the San Juan River Basin near Farmington.

Leaking ~~Underground/Above-Ground~~ Storage Tanks and Refined Petroleum Products

As of November 1999, the San Juan River Basin had approximately ~~174~~ **175** incidences where leaking ~~underground~~ storage tank sites ~~and one above-ground storage tank site~~ were reported. The majority of these reported ground water contamination cases were due to gas, oil, diesel, gasoline additives, petroleum constituents such as benzene, toluene, ethyl benzene, and xylene and solvents such as chlorinated methane, ethanes, propanes and ethylenes. The bulk of these sites are concentrated around the major industrialized areas such as Farmington, Aztec and Bloomfield in San Juan County and Dulce in Rio Arriba County. These areas typically associated with service stations, liquid petroleum storage and distribution centers, pipelines and oil extraction operations.

Total Dissolved Solids

Point source ground water contamination due to TDS is found near many of the uranium mining and milling in the San Juan River Basin near Crownpoint. TDS also results from natural limestone deposits in this area.

Landfills

Many landfills in New Mexico have received large amounts of liquid and/or industrial wastes. Ground water contamin-ation has been detected in two landfills in the San Juan River Basin. These landfills are located near Farmington in San Juan County. Contaminants include chlorinated solvents and basic-, neutral- and acid-extractable compounds and crude oil.

THE SOUTHERN HIGH PLAINS BASIN

The Southern High Plains (~~14~~**WQCC 1976d**) in New Mexico is on the western edge of the Great Plains of the United States and encompasses 5,487 square miles in New Mexico's Curry, Roosevelt, Chavez and Lea counties. There are no perennial streams in this area. The Ogallala formation, a large water-bearing aquifer, supplies practically all the water needs for this part of New Mexico. This vast resource underlies parts of eight states.

During Francisco Vásquez de Coronado's journey into the Southwest in 1598 and 1599, the Southern High Plains were referred to as "*Llano Estacado*," or the *staked plain*. Their sharp rise from the surrounding area forms an escarpment which marks the southern and western boundaries of the basin. There are no perennial streams in the Southern High Plains, although the relatively flat topography can have occasional water-filled shallow depressions called playa lakes. Also, there are several draws from which ephemeral streams appear during periods of heavy or prolonged precipitation.

The climate is generally warm and sunny during the day, becoming much cooler at night. The average temperature ranges from 57.7° Fahrenheit (°F) in Portales to 61.2°F in Hobbs. An additional indicator of the mild climate is the annual number of frost-free days. These range from 182 days near Portales to 218 near Hobbs (one of the longest frost-free periods in the State). There is an average rainfall of about 16 inches a year with most of this precipitation occurring during the summer months. There is often about five times as much precipitation during the months of May through October as there is in the other half of the year.

Four geologic ages saw fresh water-bearing rock formations deposited in the Southern High Plains: the Triassic, Cretaceous, Tertiary, and Quaternary. Although the Dockum Group, Tucumcari Shale and the alluvium do produce some usable fresh water, the Ogallala formation of the Tertiary Age produces by far the greatest amount of water and is the most important. This formation was eroded away in the Portales Valley, which was then filled with water-bearing alluvium during the Quaternary Age. Practically all water used in the basin comes from these aquifers. The waters of the Ogallala, although hard, are of generally good quality. Playa lakes constitute the only significant recharge to the Ogallala aquifer in New Mexico. Recharge, however, is probably less than a half-inch a year and is expected to be far less than withdrawals.

Surface Water Quality Concerns in the Southern High Plains Basin

The only significant surface waters in the Southern High Plains occur in the aforementioned playa lakes. Like all wetlands throughout New Mexico, these ephemeral, endorheic (internally draining) areas are considered threatened by a variety of human activities. Common problems are caused by contamination with municipal sewage effluents, stormwater runoff, hypersaline brines discharged by potash refining, petroleum industry waste-products, as well as high levels of agri-cultural chemicals, stockyard wastes and overall watershed condition. Traditional rangeland practices where BMPs have not been applied threaten these fragile and critical wildlife habitats with terrain alterations which can either obliterate a playa completely or expose it to increased levels of pluvial and eolian sedimentation, vegetative growth, and anaerobic conditions.

Ground Water Quality Concerns in the Southern High Plains Basin

The ground water contamination concerns seen in the Southern High Plains Basin include leaking ~~underground~~ storage tanks, nitrates from agricultural activities, dairy operations, septic tanks and public and private sewage treatment plants. There also are cases of petroleum, methane and TDS contamination from oil and gas field operations.

Leaking ~~Underground/Above Ground~~ Storage Tanks and Petroleum Products

In the Southern High Plains Basin there were approximately ~~153~~ **154** sites as of November 1999, where leaking ~~underground~~ storage sites had been reported ~~and one above-ground storage tank site~~. The majority of these reported ground water contamination cases are due to gas, oil, diesel, gasoline additives, and petroleum by-products. The bulk of these sites are concentrated around the major industrialized areas such as Hobbs, Tatum, Lovington in Lea County and Clovis in Curry County. These areas are typically associated with service stations, liquid petroleum storage and distribution centers, pipelines and oil extraction operations and military installations.

Total Dissolved Solids

At least one hundred thirty cases of point source ground water contamination due to oil field discharges are found near many of the oil and gas operation sites in the Southern High Plains Basin. Most are due to past practices of oil field brine disposal with its resultant contamination of ground water with crude oil, TDS, methane and chlorides.

Nitrates

Nitrate contamination is prevalent in areas where there are high densities of septic tanks and cesspools. High nitrate concentrations can also be seen around meat packing and processing plants, sewage treatment plants or dairy operations, and explosive manufacturing plants. Nitrate contamination in the Southern High Plains Basin has been reported in Lovington, Hobbs and Clovis.

Halogenated Aliphatic Compounds

Halogenated aliphatic compounds have been detected in ground water in Clovis. Degreasing solvents are the suspected source.

THE SOUTHWESTERN CLOSED BASINS

The Southwestern Closed Basins (~~15~~**WQCC 1975d**) are located in the far southwestern "bootheel" area of New Mexico. They consist of three drainage areas comprising a total of 5,990 square miles, or about five percent, of the State's land area. The individual basins and their respective areas are the Mimbres with 4,410 square miles, the Playas and its 1,410 square miles, and the Wamel at 170 square miles. The Animas Closed Subbasin has been included in discussion of the Lower Colorado Basin Plan as it falls on the western side of the Continental Divide. The overall area encompasses virtually all of Luna County, the southeast corners of Grant and Hidalgo counties, the western edge of Doña Ana County and a relatively small southwestern piece of Sierra County. The Southwestern Closed Basins' southern boundary coincides with the International Border with the Republic of Mexico, while its western edge is created by the Continental Divide and the northern and eastern limits as defined by the Rio Grande Basin.

The Southwestern Closed Basins are topographically closed basins and make no surface water contributions to any of the surrounding basins. In the upper stretches of the Mimbres River there is perennial flow. Water from the Mimbres River is diverted for irrigation purposes and a reservoir has been constructed by the New Mexico Department of Game and Fish in Bear Canyon, a tributary of the Mimbres, for conservation and recreation purposes. There are no perennial flows in the Playas or Wamel Sub-basins.

The northern part of the Basins are high mountainous wooded areas with elevations ranging from 6,500 to 10,000 feet. Much of the land is characterized by rough and broken topography, including steep mountain slopes and canyons. Intermingled with the steeper areas are gently to strongly sloping narrow valley bottoms and gently sloping and rolling uplands and ridgetops.

The southern parts of the Basins consists of broad, virtually level to gently sloping semi-desert and desert plains from which rise relatively narrow but steep and rugged mountain ridges, isolated peaks, and foothill ranges. Elevations along these parts of the basins range from 5,000 feet in the north to 4,000 feet along the south borders. The mountains and hills in these areas rise from 1,000 to 2,000 feet above the floors of the plains.

Climate ranges from arid in the southern portion of the basins to sub-humid in the northern mountains, with a narrow, semi-arid belt running through the middle. The climate of the basins is essentially dry with only the higher elevations of the Piños Altos and Mimbres mountains having a climate where perennial streams are possible.

The essential feature of the basins' climate is that evaporation exceeds precipitation. The two commonly recognized subdivisions of arid climates, desert and steppe, are present within the basins. Valley floors and lowlands are deserts; the transitional belts between the lowlands and the humid mountain areas are steppes. Average annual precipitation varies from eight to ten inches a year for most of the lowland areas, while up to 25 inches have been recorded in the higher elevations of the mountains on the northern border of the basins. Over half of the annual precipitation falls in July, August and September each year, and usually occurs as brief high-intensity afternoon thundershowers.

Average annual temperatures range from 60° F in the lower southern elevations to around 55° F in the Bayard-Silver City areas. Mountain areas average less than 50° F annually. Normal winter sunshine occurs over seventy percent of the time while summer sunshine occurs over eighty percent of the time.

Frost-free seasons average over 220 days in the southern part of the basins, decreasing to 140 in the north with some mountain areas having less than 120 days annually. Frost in the lower elevations of the basins can be expected from early November until late March. Earlier fall frost and later spring frost will occur in the northern mountain areas with increasing elevation.

Factors that control the hydrology of the Southwestern Closed Basins are integrally associated to the climate of the region. The source of all water in the basins is the precipitation that falls within the drainage area. No ground waters are known to enter the basins from outside areas.

In the Southwestern Closed Basins, the Mimbres River is the principal perennial stream. This flow in normal years is limited to the upper stretches of the river. Water that is not used for irrigation or contained in the Bear Canyon Reservoir infiltrates into the ground upon leaving the mountains and enters the floor of the basin near the Grant-Luna counties line. Flow beyond this point is infrequent and usually reaches only to the Florida Mountains. The channel across the lower half of the basins is ill-defined, although runoffs from unusually large storms may reach the Mexican Border.

Bear Canyon Reservoir is located near the confluence of the Mimbres River and Bear Canyon. The reservoir is capable of impounding 700 acre-feet of water for conservation storage and recreation. Surface water for irrigation exists only in the area of the perennial flow of the Mimbres River, although it is used for stock watering purposes in other areas.

There are four declared underground water basins wholly or partly within the Southwestern Closed surface drainage Basins. These include the Mimbres, Animas, Playas and Nutt-Hockett underground water basins. The Mimbres aquifer underlies 4,279 square miles of surface area within portions of Luna, Grant, Sierra, and Doña Ana counties. The Animas Valley aquifer lies beneath 426 square miles of surface area with approximately 30 square miles in the Southwestern Closed Basins. The Playas Valley aquifer underlies 515 square miles of surface area in Hidalgo County, while the Nutt-Hockett aquifer lies under 133 square miles of surface area within portions of Luna, Sierra, and Doña Ana counties.

The principal aquifers in the Mimbres Subbasin are the alluvium, Bolson fill, and Gila conglommerate. It is the Gila conglomerate which provides the principal source of water for the towns and villages in the northern mountainous portion of the basins. The alluvium in the channels and under the flood plains of the creeks and washes may locally contain appreciable amounts of water at shallow depth, but generally will not sustain large yields for prolonged periods. Great thicknesses of Bolson deposits appear in most of the large valleys and constitute ground water reservoirs of significant capacity.

Surface Water Quality Concerns in the Southwestern Closed Basin

There are 67.3 assessed river miles in the Southwestern Closed Basins that are listed as partially or not supporting their designated uses. The specific pollutant or threat in this lack of support are temperature, pathogens, stream bottom deposits and dissolved oxygen. The probable sources of these pollutants are hydromodification, agriculture, grazing, resource extraction, and natural and unknown causes. The singular toxin currently known to be at an acute level of concern within this basin is zinc.

The Southwestern Closed Basins have 8.6 assessed lake acres at the Bear Canyon Reservoir that are listed as only partially supporting their designated uses. The specific pollutant or perceived threat in this nonsupport include low dissolved oxygen, excessive nutrients, siltation and mercury in fish tissue. The probable sources of these causes are agriculture and overall watershed condition.

Ground Water Quality Concerns in the Southwestern Closed Basins

The majority of the ground water quality concerns in the Southwestern Closed Basin are associated with approximately 69 leaking underground storage tanks, mining and milling operations, nitrates from septic tanks and cesspools in Deming, and chlorinated solvents in Deming.

Total Dissolved Solids

The majority of the ground water problems found in the Southwestern Closed Basin are from sulfates, metals and TDS. The source of these problems are from heap-leach operations, copper milling operations and lead milling operations. Many of these sites also have acidity problems associated with them.

Halogenated Aliphatic Compounds

Halogenated aliphatic compounds have been detected in ground water in Deming. Degreasing solvents are the suspected source.

THE WESTERN CLOSED BASINS

The Western Closed Basins (~~16~~**WQCC 1974b**) in west-central New Mexico consist of two major drainage areas: the North Plains Subbasin, which is mostly in Cibola County but extends southward into

Catron County, and the San Augustin Plains Subbasin, which is mostly in Catron County, yet extends eastward into Socorro County. There are no distinct communities in the North Plains Subbasin. Communities in the San Augustin Plains Subbasin are Datil and Horse Springs. The Western Closed Basins lie immediately east of the Continental Divide, which forms their western and southern borders, while the Rio Grande Basin bounds the eastern extremities.

The North Plains Sub-basin encompasses an area of approximately a thousand square miles. It is bounded on the east by Cebolleta Mesa, and on the south and southeast by the sedimentary and volcanic rocks of the Datil Mountains. Sedimentary outcrops northeast of the Zuni Mountains loosely define the northern boundary of the basin. The North Plains derives its name from a broad area of low relief that occupies the central and western parts of the basin. This area is mostly a grassy plain underlain at very shallow depths by basaltic lava flows. At low elevations in the north and eastern parts of the basin lava beds cover the surface. It is not definitely established that the North Plains Subbasin is truly closed at its north end; the basin here is covered by a lava flow, and it is possible that some water escapes northward from the basin through, or under, the lava beds toward Rio San Jose.

The San Augustin Plains Sub-basin, an area of approximately 1,965 square miles, is bounded on the east and north by the San Mateo, Gallinas and Datil mountains, on the south by the Tularosa, O-Bar-O, and Pelona mountains, and on the west by the Mangas Mountains. The San Augustin Plains are featureless grass-covered lands at the center of the San Augustin Plains Subbasin. This area in earlier geological times was occupied by pluvial Lake San Augustin which covered a maximum area of 255 square miles. The San Augustin Plains Sub-basin is topographically closed, having superficial internal drainage around its perimeter.

The Western Closed Basins have no perennial streams and none of the intermittent streams are named. Generally, waterways are dry and poorly defined. Ephemeral streams that originate in the bordering mountains occasionally carry floodwaters into the basins. The flood flows spread out over the gravelly soil and soon disappear into the ground or evaporate. During periods of heavy precipitation, water is contained in several natural lakes in the western part of the North Plains and in a few small playas in the northeastern part of the San Augustin Plains. At the west end of the San Augustin Plains a large playa which covers approximately 35 square miles occasionally contains water.

Precipitation averages about fifteen inches annually in both basins. Within the center of the basins, annual precipitation is fourteen inches or less; in the surrounding highlands sixteen inches or more are received annually.

The principle aquifer in the North Plains is composed of thick basalt of Quaternary age that underlies the North Plains and extends over half of the total area of the basin. Sandstones of Jurassic and Cretaceous ages, which are usually dependable aquifers, are in adjacent areas. In the northern part of the basin the San Andres Limestone and Glorieta Sandstone, both of Permian age, are known to contain water.

The principal aquifer in the San Augustin Plains is formed by the bolson deposits of Quaternary age that underlie the middle of the basin. Volcanic rocks of the Datil Formation of Tertiary age which surrounds the basin may contain small quantities of water in some localities. Some water may be present in the small patches of Gila Conglomerate Quaternary alluvium which are widely scattered within the basin. It also seems possible that some water may be present in the basalt and andesite flows of Quaternary age which cover large areas on the south and west edges of the basin.

Much of the area of the North Plains is underlain by slightly saline water, and saline water is known to be present within the San Augustin Plains. Water analyses are available for a few wells in the northeastern part of the North Plains and the southwestern part of the San Augustin Plains. Limited data is available for other localities within the Western Closed Basins. The community of Magdalena's water system, just east of the basin, is tested annually. Records show this water is of high quality. The depth-to-water in wells within the North Plains and the San Augustin Plains ranges from less than fifty feet to about 200 feet. The depth to water increases away from the middle of the basins and is 500 feet or more in the higher elevations of the mountainous areas around the basins.

Ground Water Quality Concerns in the Western Basins

The majority of the ground water quality concerns in the Western Closed Basins are from 5 leaking ~~underground~~ storage tanks in Datil.

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